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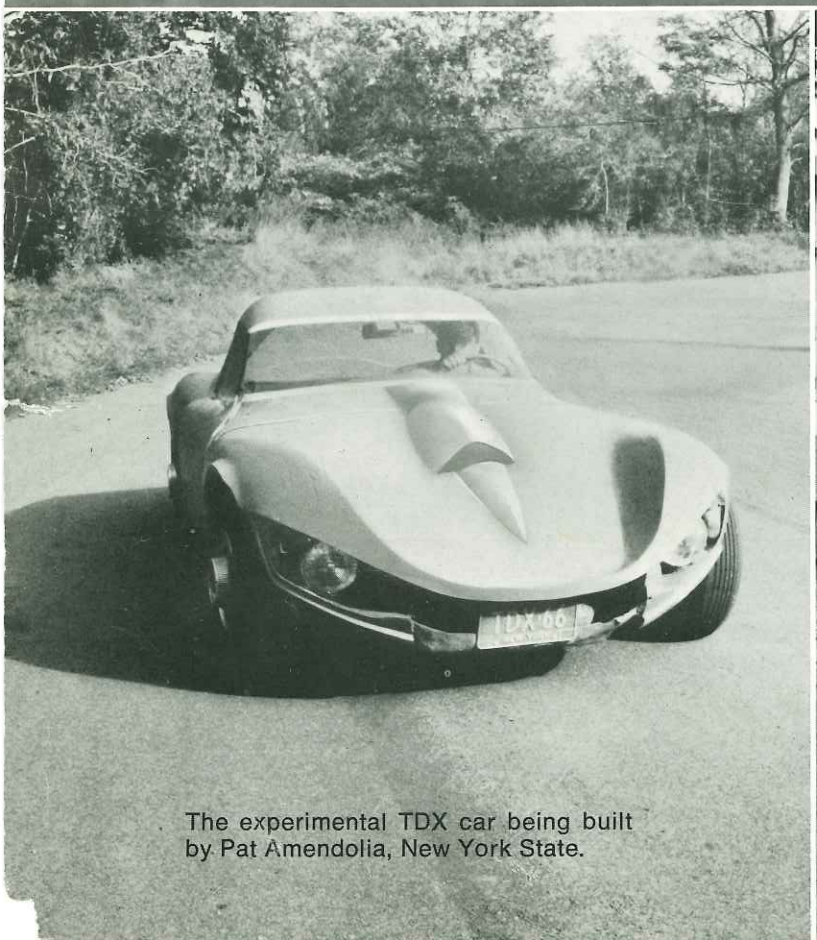
The rolling showcase for engineering plastics

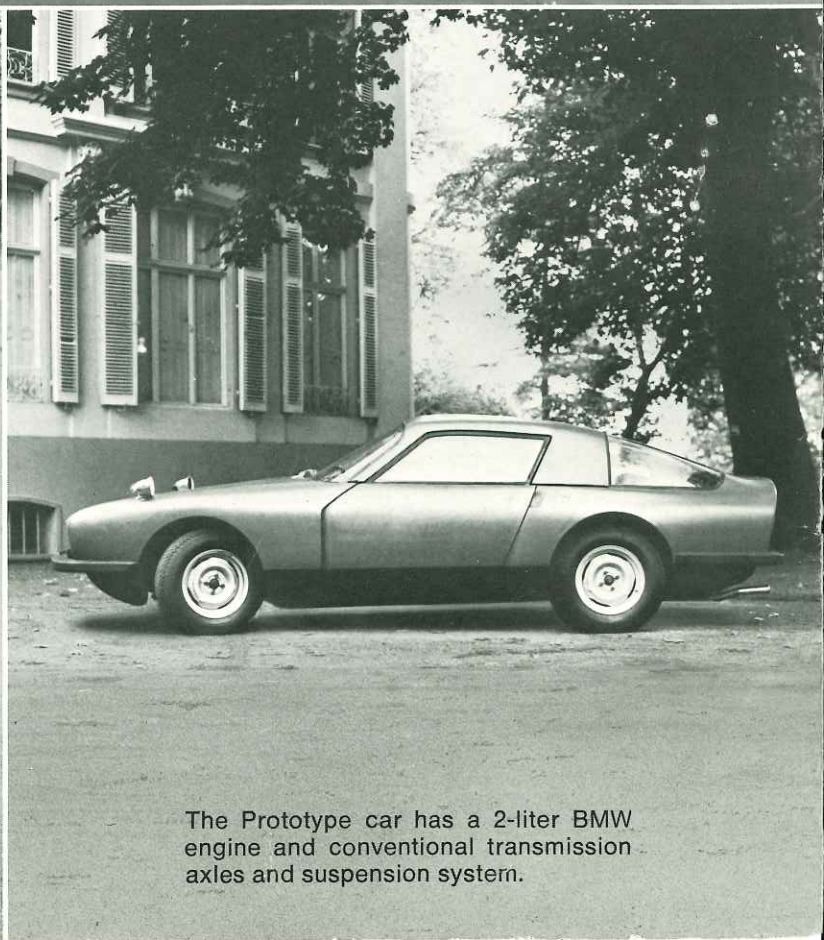
MOBAY®

1968 is the 100th Anniversary of the plastics industry. A fitting symbol to mark this Centennial milestone is the all-plastic auto prototype described in this report. This triumph of plastics engineering brings the first 100 years to a highly satisfactory close as it launches the second century of progress on a well-tuned note of optimism.

The car's chassis withstood load-to-failure tests of 7.1 tons and more than 6 million cycles. In road tests, the car exhibited good handling characteristics at speeds up to 105 mph, and the body had excellent noise and vibration damping ability.



The experimental TDX car being built by Pat Amendolia, New York State.



The Prototype car has a 2-liter BMW engine and conventional transmission axles and suspension system.

Expand Your Design Parameters with Urethane Foam-Plastics Construction

Exactly 100 years ago, the plastics industry was born in the form of a cellulose nitrate billiard ball. Since then, hundreds of new plastics have been developed and have found their way into just about every area of human and industrial activity from artificial heart pumps to missile nose cones.

Advent Of Engineering Plastics

It has only been in the past 10 years, however, that the so-called engineering thermoplastics have evolved. Significantly, two of these high-performance materials—polycarbonate and the urethane family of plastics—were inventions of Farbenfabriken Bayer AG, an international chemicals and plastics manufacturer who has now combined these and other engineering plastics into an all-plastic auto chassis prototype.

As a subsidiary of Farbenfabriken Bayer, Mobay Chemical Company introduced urethane and polycarbonate product technology to U. S. markets in the 1950's. Appropriately, Mobay is now introducing the new foam-and-plastic auto to American design engineers.

The real significance of this design innovation goes far deeper than a first-glance impression might reveal. The marriage of various types of high-strength plastic sheeting materials with high-density rigid urethane foam as the core section contains a message for every field of product engineering where high strength-to-weight ratio, low tooling and production costs, assembly-line scheduling, and almost unlimited flexibility in materials and processing methods are essential or even desirable values.

But, in Detroit, the message is especially loud and clear.

Actually, the use of engineering plastics by the auto industry is not a new idea, either in this country or abroad. All-plastic body shells have appeared in commercial stock model cars since the 1950's; have popped up even earlier in Europe. But these early probes were essentially experiments in the straight substitution of plastics for metals in the conventional umbrella or canopy type of standard body shell.

What is really new about the German concept is that, for the first time, plastics have completely replaced metals throughout the chassis in functional, structural ways. Where you find plastics in the car is not nearly so surprising as where you don't find metal—such as in body posts, load-bearing supports and the understructure. Because of this, the innovation may well have more far-reaching effects in industries other than the automotive field where the advent of the all-plastic car has been expected for some time.

Perhaps the most significant design feature of this prototype is the way the self-supporting, integral and compact chassis structure has been built entirely of high-strength engineering plastics, either separately or as facing materials in a sandwich construction employing the rigid urethane foam core. This frees the designer from the stereotype X-frame platform so that body styling and engineering can be oriented toward the total rolling package idea rather than an implanted capsule on a rigid frame.

This structural concept has been a mechanical engineering reality in transportation equipment in Europe for over a decade. Railroad cars and buses, also developed from Farbenfabriken Bayer AG prototype designs, have been in service since 1957.

Variations of this same concept have also been gaining momentum elsewhere: Another experimental all-plastic auto chassis, the TDX, is now being constructed by a private designer in New York. It, too, will have a urethane foam-cored monococque shell instead of a conventional frame, and will feature other innovations such as a tubular drive shaft of MERLON® polycarbonate, also with a foam core.

The urethane foam-core sandwich concept has become a mainstay of the building industry in the U. S. owing to its favorable economics, inherent insulating features, high strength-to-weight ratio, low initial cost and stable physical properties imparted by this type of panel construction.

Other application markets being developed for molded high-density urethane foam-and-plastic combinations include furniture and fixtures, appliance housings, mobile homes and transport units, marine, aerospace and rapid transit equipment, shipping containers and many types of industrial and commercial storage facilities where competitive economics set the tempo of change.

Chassis Construction

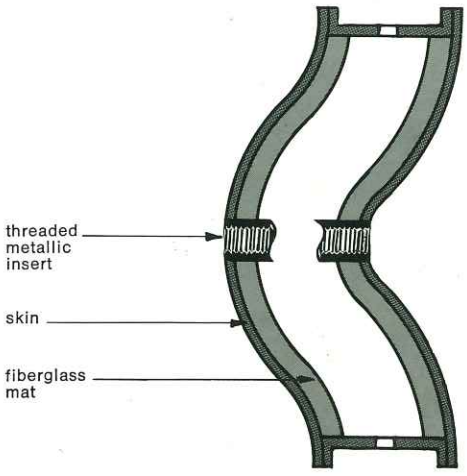
The technique of production for foam-and-plastic sandwich components, as employed in the test model car, is quite simple and straightforward:

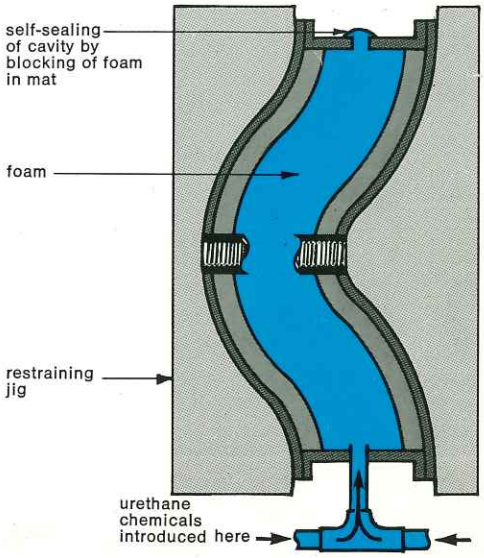
1. Sheets of high-impact engineering plastic are thermo-formed to produce the top and bottom "skins" in the desired shape.

2. Skins are lined on the insides with glass fiber mats, then cemented together to form a cavity.

3. Metallic inserts to help stabilize or transmit loads from engine, transmission, axles and body are bonded in place prior to the foaming step.

4. Assembly is placed in a restraining jig or press and urethane chemicals are injected into the cavity between facing sections. The foam mixture expands to a compressed density that averages about 6 pounds per cubic foot, with a gradient ranging from 4 pounds per cubic foot at core center to 12-25 pounds per cubic foot at the highly densified zones near the skin surfaces.



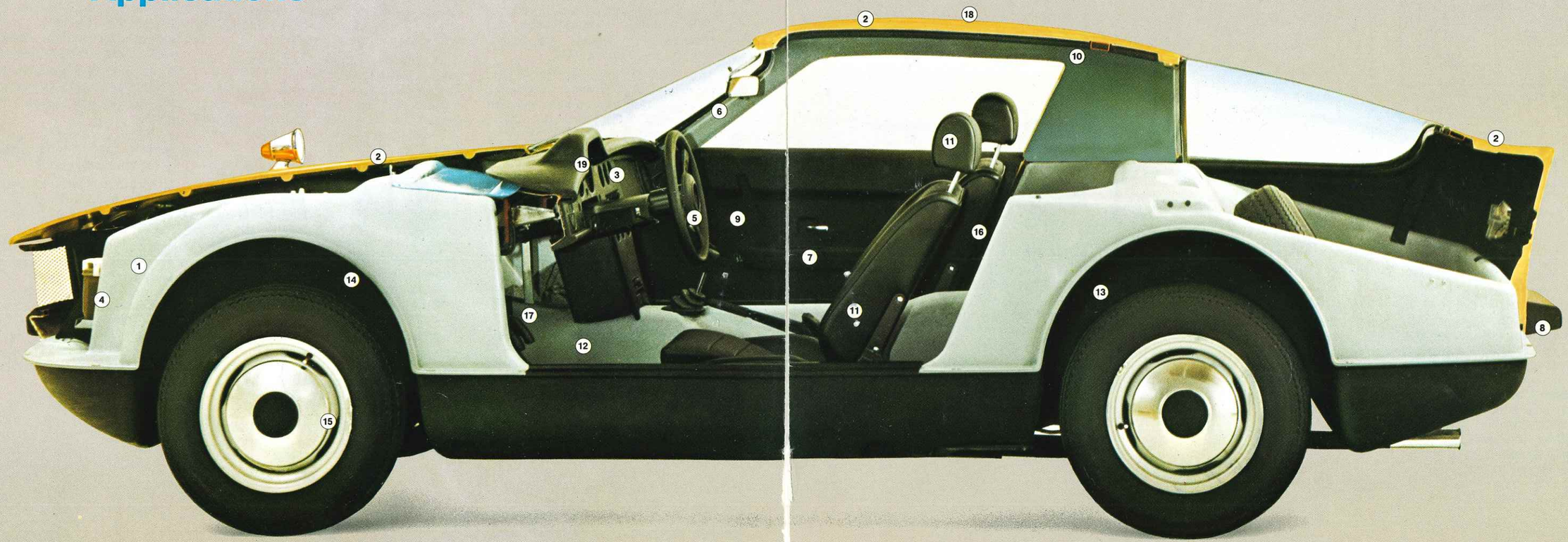


1. FENDERS • The front fenders are of rigid urethane foam-core sandwich construction similar to the chassis. The rear fenders are of rigid urethane foam-core sandwich construction with thermoplastic facing.

2. ENGINE-HOOD, ROOF, TRUNK LID • Produced from polyurethane duromer, an integral-skin, high-density rigid urethane foam (FIGURE 1, Page 6).

The Prototype Car Demonstrates the Utility of Plastics for Broadscale Applications

3. INSTRUMENT PANEL PADDING • The instrument panel padding, along with most of the other interior padding, is an integral-skin (self-skinning), semi-rigid urethane foam. This tough, abrasion-and tear-resistant plastic was specified because of its outstanding energy absorption, low weight, vibration damping, and leatherlike appearance. First step in the production of these parts is preparing the mold assembly, including proper placement of reinforcements, if required. A cold-curing, semi-rigid foam system is introduced into the mold through a mixing/metering machine. After a few seconds, the reaction mix begins to foam and fill the cavity. As the expanding foam contacts the mold surface, a relatively thick non-porous skin is formed. This skin exactly duplicates the mold surface. Demolding is usually possible in 3 to 7 minutes. Density is controllable from 10 to 30 pounds per cubic foot.



13. AUXILIARY SPRINGS • Cellular urethane elastomers (30 lbs/cu ft approximate density) exhibit an extremely wide deformation range under static and dynamic loading. This feature, combined with excellent resistance to oil, tear and abrasion, was the primary reason for choosing this material.

14. DUST HOOD AND BELLOWS • Blow-molded urethane elastomers. These parts have high tear and oil resistance and excellent low temperature stability. Also, translucence permits visual observation of lubrication where necessary.

15. TIE-BAR BEARINGS • Injection-molded urethane elastomer parts have high abrasion, oil and tear resistance. They are also relatively maintenance-free and provide a degree of vibration damping.

Integral-skin, semi-rigid urethane foams were also used for the following parts:

4. CUSHION MOUNTINGS for front headlights and bumper.

5. STEERING WHEEL COVER AND HORN RING PADDING

6. "A" PILLAR PADDING

7. ARM REST

8. REAR BUMPER polyurethane elastomer, steel-reinforced.

9. DOOR INTERIOR laminated from PVC, semi-rigid urethane foam and fiberboard (FIGURE 3, Page 6).

10. ROOF INTERIOR • Composed of PVC cover film over a semi-rigid urethane foam.

11. SEATS AND HEADRESTS • Flexible urethane foam of several densities and produced by various methods give optimum seating comfort with safety requirements. Seat and headrest foam, as well as other interior foam parts, deliver deceleration below 80 G's when tested per SAE testing procedures.

12. CARPETING • Semi-rigid urethane foam backing provides thermal and sound insulation, reduced driver fatigue, cleanability. In addition, the high friction characteristics of urethane surfaces permit easier installation by eliminating the adhesive required for conventional carpet backings.

In addition, urethane elastomer is used for:

16. DOOR CLOSING GUIDES

17. FOOT PEDAL BUSHINGS

18. FINISHED COATING • A light-stable urethane coating provides outstanding weather and chemical resistance, gloss retention, color permanence and excellent adhesion to a wide variety of substrates.

19. COVERS FOR CONTROL LAMPS • High heat stability of polycarbonate permits use of high-intensity light source for illumination.

The Duromer Production Process

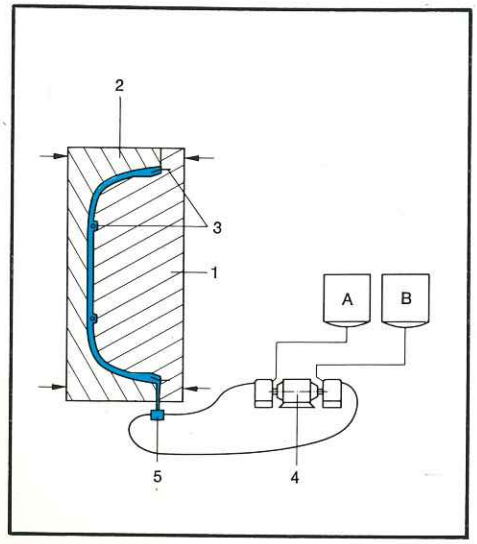


FIGURE 1. Equipment arrangement for the duromer process.

Mold cavity is formed between mold halves (1 and 2). Reinforcements (3), if necessary, are positioned. The foam chemicals are drawn from storage tanks (A and B) by a metering pump (4), piped to a mixing head (5), and injected into the cavity.

A few seconds after entry, the mixed chemicals start reacting to form a solid polymer. Concurrently, the reacting mixture expands approximately 2 to 4 times to completely fill the cavity. As the expanding foam contacts a mold surface, a dense skin of controllable thickness is formed. After approximately one minute, the expansion is completed. Demolding is possible within 4 to 10 minutes, depending on part size and configuration. The product is characterized by an overall density of 30 to 80 pounds per cubic foot. The density gradient in a typical cross section is similar to that shown in Figure 2.

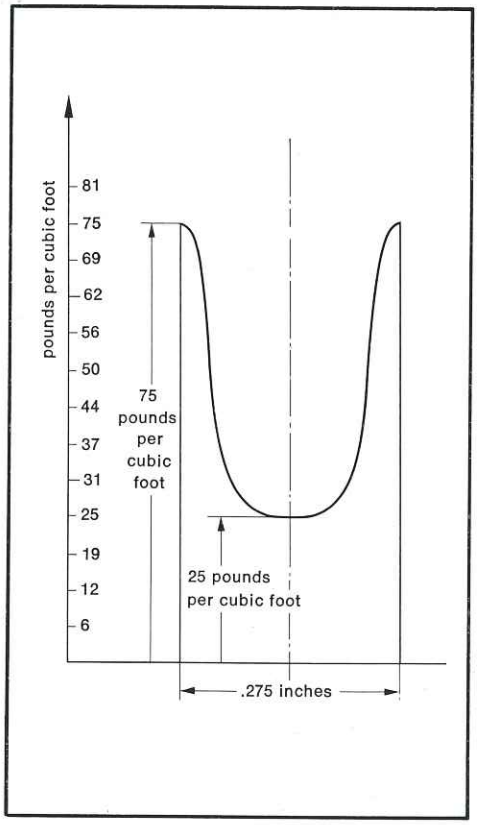


FIGURE 2. Density variation in cured duromer. Compaction is highest at skins, lowest at core.

The duromer process permits the manufacture of large surface areas, reinforced or unreinforced, and high strength-to-weight components. Benefits? Low mold costs (comparable to injection molding), low mold pressure and lower injection equipment costs.

The PVC/Fiberboard Production Process

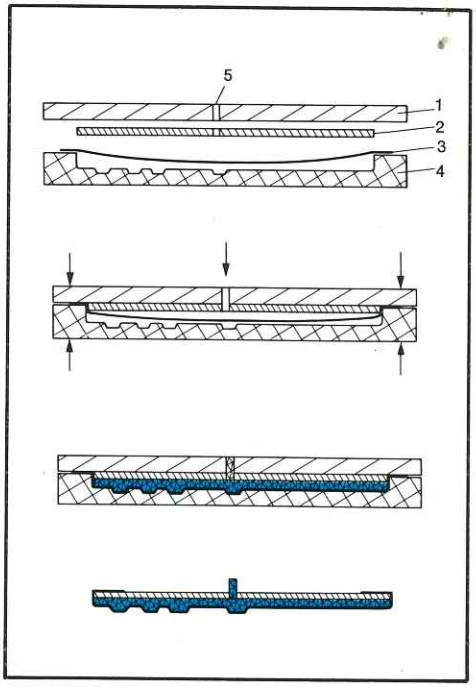


FIGURE 3. Procedure for production of sandwich laminate composed of vinyl, fiberboard skins and a semi-rigid urethane foam core.

A PVC skin (3) is inserted in the negative half of the mold. A fiberboard plate (2) is placed over the PVC skin and the mold lid (1) is closed. Foam chemicals are pumped through the orifice (5) into the cavity between the PVC and the reinforced plate. The reacting mixture expands, forcing the PVC against the mold surface (4). At the reaction temperature and pressure, the PVC is forced to duplicate the mold contours. The semi-rigid foam firmly bonds the PVC to the fiberboard plate.

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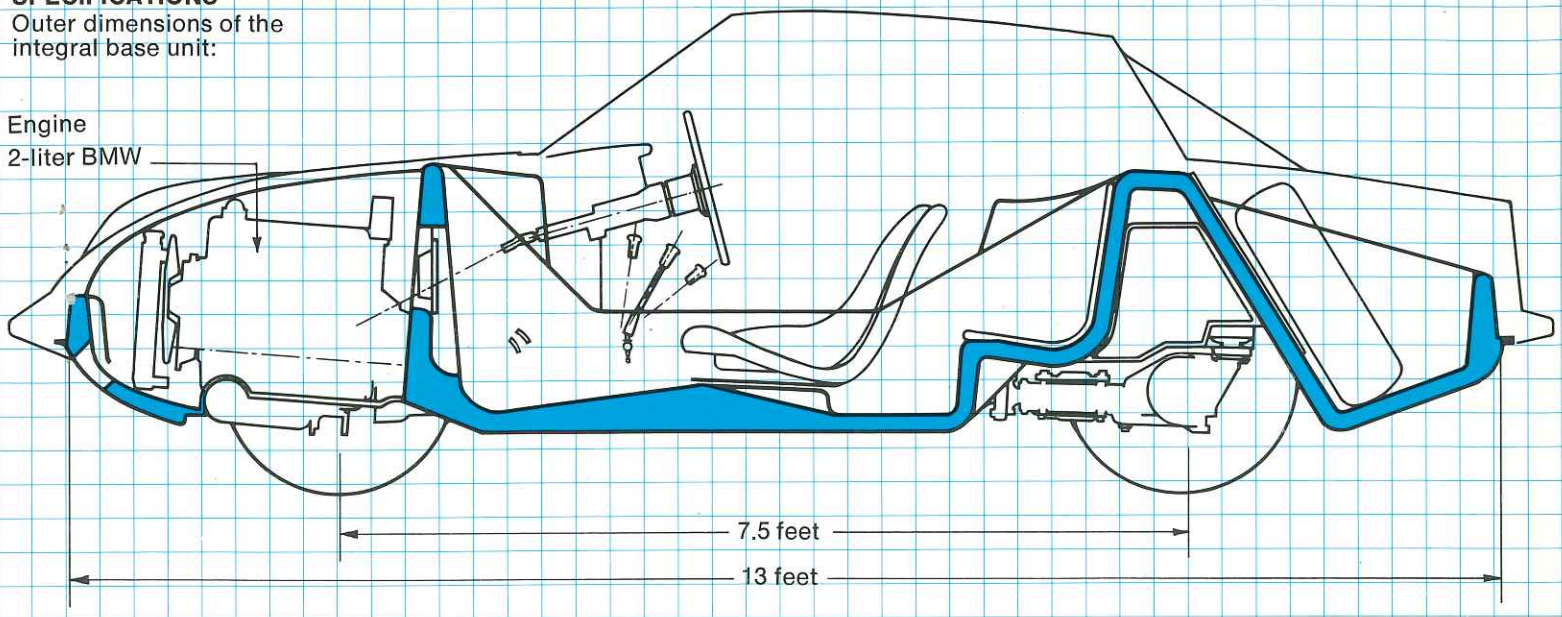
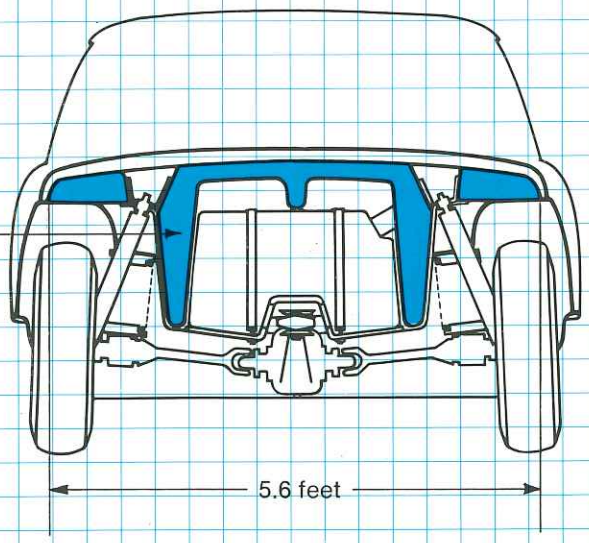
SPECIFICATIONS
Outer dimensions of the integral base unit:

Engine
2-liter BMW

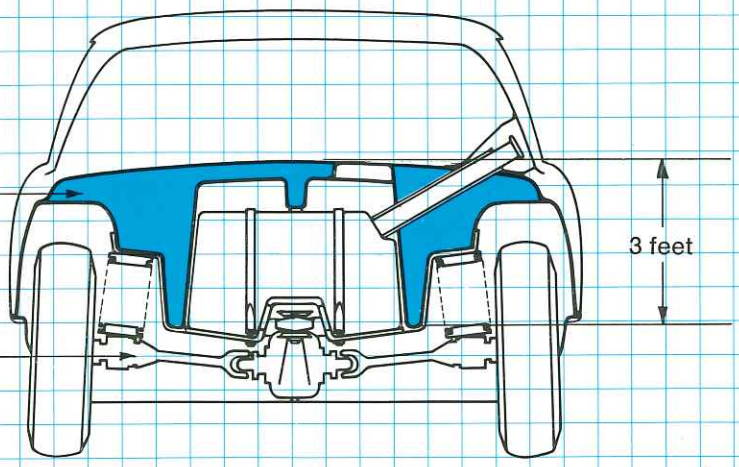


Weight of base unit alone
375 pounds



Unloaded weight of base unit ready for driving
1648 pounds

Axles
(standard production)



Mobay technical personnel are well-grounded and knowledgeable in all of the fabricating and processing techniques mentioned in this report. Additional information and assistance on the application of urethane and polycarbonate materials to design areas other than automotive uses is also immediately available from Mobay. We will be glad to discuss this technology and assistance program with qualified design or development engineers who have a practical application under consideration. A brief description of your application and physical property requirements, on your company letterhead, will enable us to process your inquiry more promptly.

Mobay Chemical Company

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